

Selenium management for coal mining: briefing to the Alberta Coal Policy Committee

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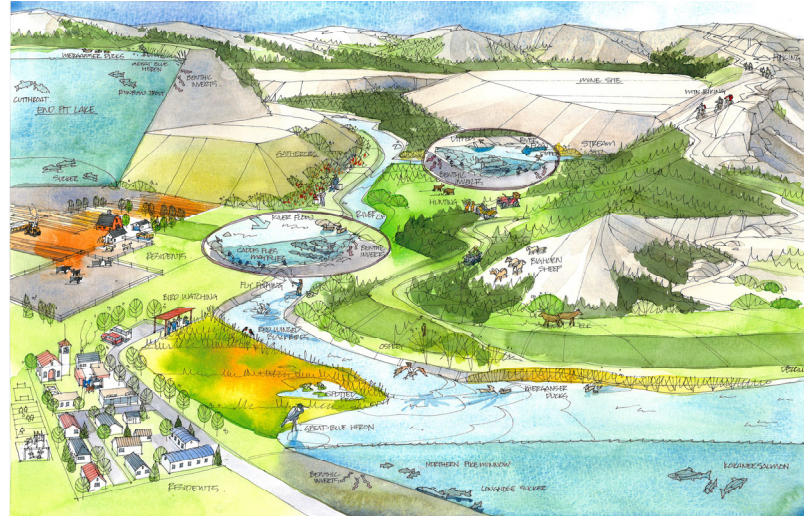
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Introduction

Alberta's Coal Policy Committee invited Mr. Guy Gilron and Dr. Gord McKenna to provide an independent brief – in advance of discussions on June 9th, 2021 – regarding various aspects of selenium management at Rocky Mountain coal mines.

Six questions were provided to Guy and Gord, for consideration prior to those discussions.

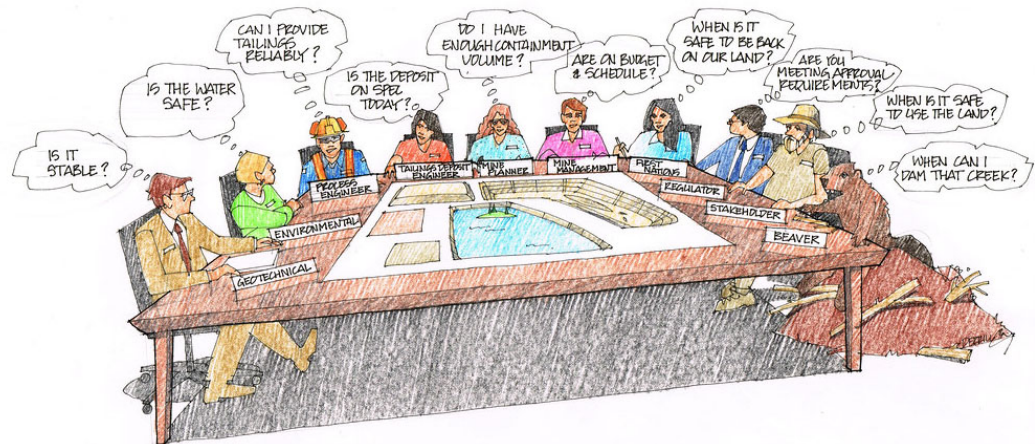
This presentation provides an overview to kickoff the discussion



Illustrations by Derrill Shuttleworth

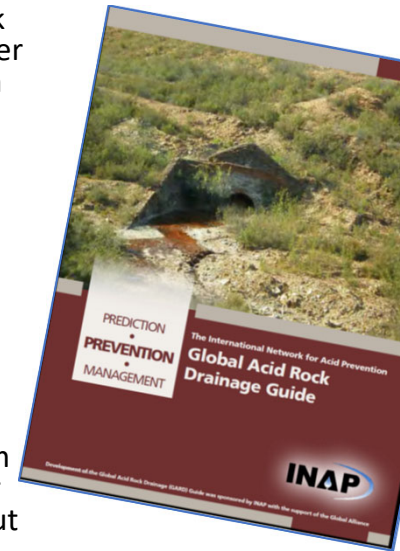
Expertise & independence

- Gord and Guy each bring over 30 years of expertise to the discussion of selenium management including work at Rocky Mountain coal mines in BC and Alberta
- Both Gord and Guy are appearing today as independent technical experts. Opinions expressed are our own.
- The briefing document provides more details regarding our independence and declaration of potential conflicts of interest.
- We are not experts in decision making regarding policy making or approvals for mining. But we do have expertise in mining, landform design, biology, selenium toxicology, and selenium management to share. We are pleased to have this opportunity to provide independent advice and recommendations to the Committee to aid in its work to help mines, Indigenous Peoples, local communities, and regulators to work together.



What are the current world practices (standards) (best available technologies or practices) for managing selenium contamination as a result of surface coal mine activities?

- Selenium is an issue in **some geographic areas** (controlled by bedrock geology) and relate to agricultural runoff, mine waste, and waste water treatment effluent. An issue downstream of various types of mines in **many countries**.
- Most international practice involves **collection and treatment** of waters with elevated selenium.
 - Golder (2020), commissioned by the North American Metals Council Selenium Working Group, provides the most up-to-date review of selenium treatment technologies
- Technologies for controlling metal leaching and acid rock drainage (**ML/ARD**) from **hardrock mines** are very similar to those being employed for selenium management – there is a rich literature.
- In Rocky Mountain coal mines, the main issue is oxidation of selenium in **mine rock piles** and leaching of selenium into receiving waters. For historical rock piles, collection and treating is the main technology, but new rockpiles are being designed from the “bottom up”
- Landform design is one of several processes that can be used to set up and operate an **effective selenium management** program. Such an approach is becoming more common in Rocky Mountain coal mines.
- Mines are required to file and follow **management plans**, some specific to selenium, some under the general banner of water management.
- **Our recommendation:** *The Government of Alberta should set out specific expectations for coal mines with regard to selenium management; this should include recognizing differences between historical/abandoned mines, proposed mines, existing mines, and closed mines. For each abandoned mine in the province, the Government of Alberta should determine which selenium management methods should be applied, and expedite implementation to meet the mine’s EPEA permit goals/objectives/compliance criteria.*

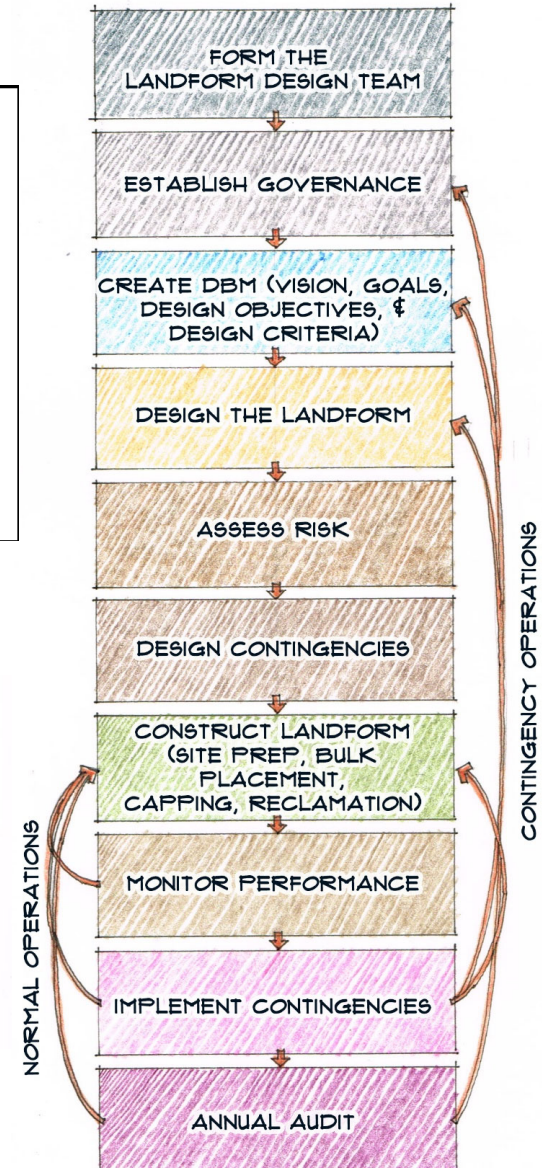
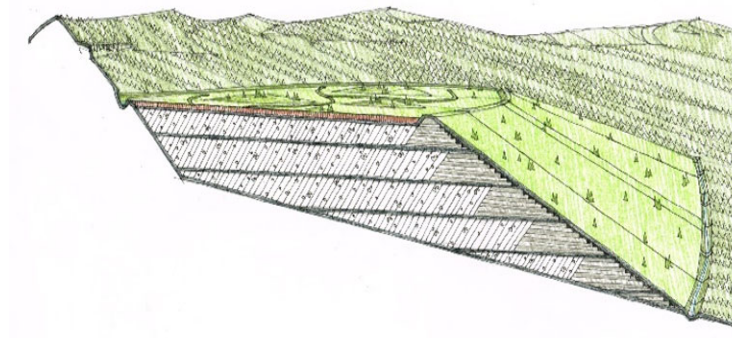
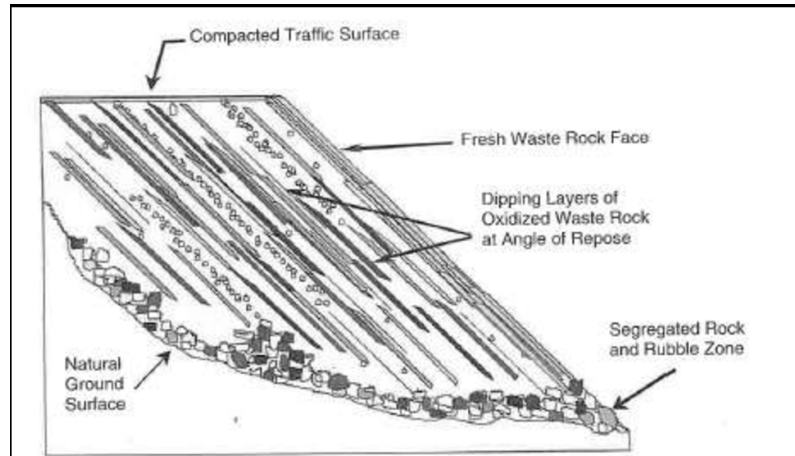


Selenium management for
Rocky Mountain coal mines
Technology readiness level
(TRL)
(system modified from
NASA 2017)

Type	Technology		Rocky Mountain coal mine selenium management technology readiness level TRL		
Mining methods	Underground mining	4		Advanced technology	Proven technology
	Selective mining	8			
	Selective handling	7			
Source control	Siting mine rock dumps	8			
	Foundation preparation	7			
	Controlling internal structure	7			
	Controlling bacteria (temporary)	7			
	Cover systems	7			
	Blending mine wastes / codisposal	8			
	Add reducing agents / enhanced microbial reduction	4			
	Submergence	8			
	Schedule and timing	4			
Water management	Understanding baseline conditions	8			
	Diversions	9			
	Covers to shed water	4		Int experience MLARD	
	Lotic discharge	9			
	Rockdrains	9			
	Surface water hydrology	8			
	Managing seepage and groundwater	8			
Mitigation	Surface and groundwater collection	6			
	Saturated rock backfill reactor	7			
	Biochemical reactors	7			
	Pit lakes	7			
	Active water treatment	7			
			Research	Dev	Comm

The key is selection and integration of the various technologies into a robust selenium management system

<https://www.semanticscholar.org/paper/Waste-Rock-Dump-Management-and-Stability-Evaluation-Olivier/4afcc1e169dc2b631c395ead9d0a3ff53d6ee94c>



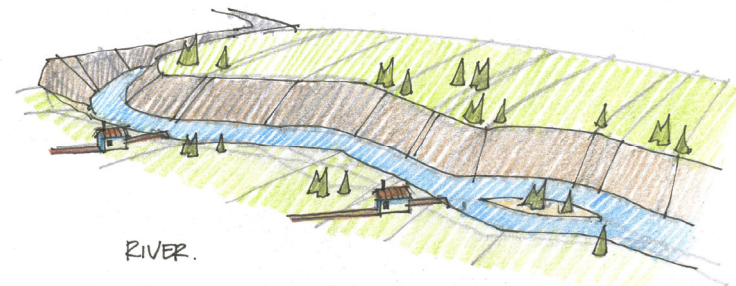
How is selenium
monitored in surface
and groundwater on
and adjacent to coal
mines?

- varying degrees/various purposes on, and adjacent to, mine sites
- extent and intensity related to the overall magnitude of exceedances of selenium in water on site and leaving the site
- The three major purposes:
 - understanding site water balance
 - research and development
 - regulatory compliance
- approach and design of these monitoring programs will align specifically to the purposes listed above
- selenium concentrations in groundwater routinely monitored as part of the above-mentioned programs at mine sites, primarily to understand the relative proportion of aqueous selenium leaving a site that seeps into groundwater vs surface water runoff
- ***monitoring of aqueous selenium concentrations in surface water and groundwater considered “standard practice” across all coal mines (operating and closed) in Canada.***
- ***monitoring programs are becoming more comprehensive, and the resulting data are being used to understand, and more effectively manage, selenium***



What monitoring information is currently available for selenium in our river systems downstream from active and historic coal mining projects?

- the only consistent monitoring information/data (water quality sampling and analysis) available with respect to aqueous selenium in river systems downstream of mines, comes from proponents
- all of the above-mentioned activities are conducted according to specifications in *EPEA* permits, are reported to AEP, and are publicly-available
- sampling and analysis can be and are carried out by both provincial (AEP, AER) and federal (Environment and Climate Change Canada) enforcement officers visiting mines for environmental compliance inspections, ***there are no regular, routine monitoring programs conducted by either federal or provincial departments/ministries***
- ***cumulative effect watershed monitoring programs have not been established or implemented for water bodies downstream of active or historic coal mines***



Recommendations

- **Recommendation:** AEP should be consulted for an update specific to selenium monitoring in Alberta rivers and lakes in the vicinity of coal mines.
- **Recommendation:** Alberta Government establish an integrated regional aquatic monitoring program for the Eastern Slopes that includes a formal water-quality sampling component with a database (accessible on-line)
 - The program should:
 - monitor fish tissue (and other biota) relative to selenium
 - be designed, carried out, and analyzed in collaboration with the mines, local communities, and Indigenous Peoples
 - include surface water and groundwater sampling results from compliance monitoring by individual mines
 - The sampling should complement data from existing stream-flow measurement stations.
 - Most importantly, this work should be linked to the Alberta Coal Policy.

Must a selenium management and mitigation plans be filed for current coal mining proposals? Are there standard conditions for handling selenium that must be applied to approvals for coalmines?

- Yes
- Selenium management and mitigation plans (SeMMP) have recently (last 5-10 years) become a requirement for coal mines
- current expectation that new coal mine proposals include SeMMPs for the purposes of:
 - evaluating project sustainability (feasibility study)
 - obtaining environmental assessment (EA) certificates, and,
 - mine permitting (in Alberta (AB), under EPEA permits; in British Columbia (BC), *Mines Act* permits).
- Selenium Management Options Analysis:
 - evaluate the site-specific opportunities for managing/mitigating/treating selenium.



An example table of
contents of a
standardized SeMMP

1.0	INTRODUCTION
2.0	REGULATORY FRAMEWORK
3.0	CURRENT CONDITIONS
4.0	SELENIUM CONCENTRATION PREDICTIONS
5.0	WATER QUALITY OBJECTIVES FOR SELENIUM
6.0	SELENIUM MANAGEMENT ACTIVITIES
7.0	AQUATIC ENVIRONMENTAL MONITORING PROGRAM
8.0	RECORD KEEPING AND REPORTING
9.0	ADAPTIVE MANAGEMENT
10.0	REFERENCES
APPENDICES	
Appendix A	Water Quality Sampling Results
Appendix B	Selenium Management Options Analysis
Appendix C	Conceptual Water Management Design
Appendix D	Hydrology Report
Appendix E	Selenium Load Balance Model
Appendix F	Selenium Source Terms

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Continued.....

- linked to other aspects of site environmental management plans, including:
 - site water management (dealing with other chemicals of concern, potential acid rock drainage),
 - explosives management (since nitrate can often be co-treated with selenium), and
 - calcite management.
- for this and other reasons, it is crucial to develop an integrated approach to site water management, which includes the management of selenium
- SeMMPs are more often linked to the financial security bond for a mine (e.g., MFSP in AB), given the potential significant expenditures associated with active selenium treatment systems and other non-treatment system mitigations
- ***numerous operating coal mines, proposed coal mine developments and mines in suspension have comprehensive SeMMPs; these are to be considered in the realm of “standard practice”.***

Main messages

phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453
arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904
antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90

- Elevated selenium in water downstream from coal mining is a **serious issue**, which can potentially have major impacts on the aquatic animals (fish, aquatic birds) and the sustainability of coal mining.
- Selenium needs to be **managed and regulated**, and both of these activities should be informed by the emerging science.
- Selenium management is a key aspect of landform design, mine design, construction, operation, reclamation, and aftercare.
- Selenium management should utilize a **multi-pronged approach**, which includes good design, the application, implementation and integration of various mitigation and treatment strategies and technologies, and a comprehensive monitoring program developed as part of the overall management system.
- **Collaboration** related to selenium management with all stakeholders is necessary to achieve a common vision and common goals.
- Selenium is the focus of this presentation. However, selenium management is just one of many **environmental issues** that need to be identified, designed for, and managed. The **integration** to achieve the vision, goals, and objectives for operating and reclaimed mine sites is the focus on landform design (LDI 2021), and a major focus of Rocky Mountain coal mining, more generally.

Discussion

